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**Volume I
EXECUTIVE SUMMARY**

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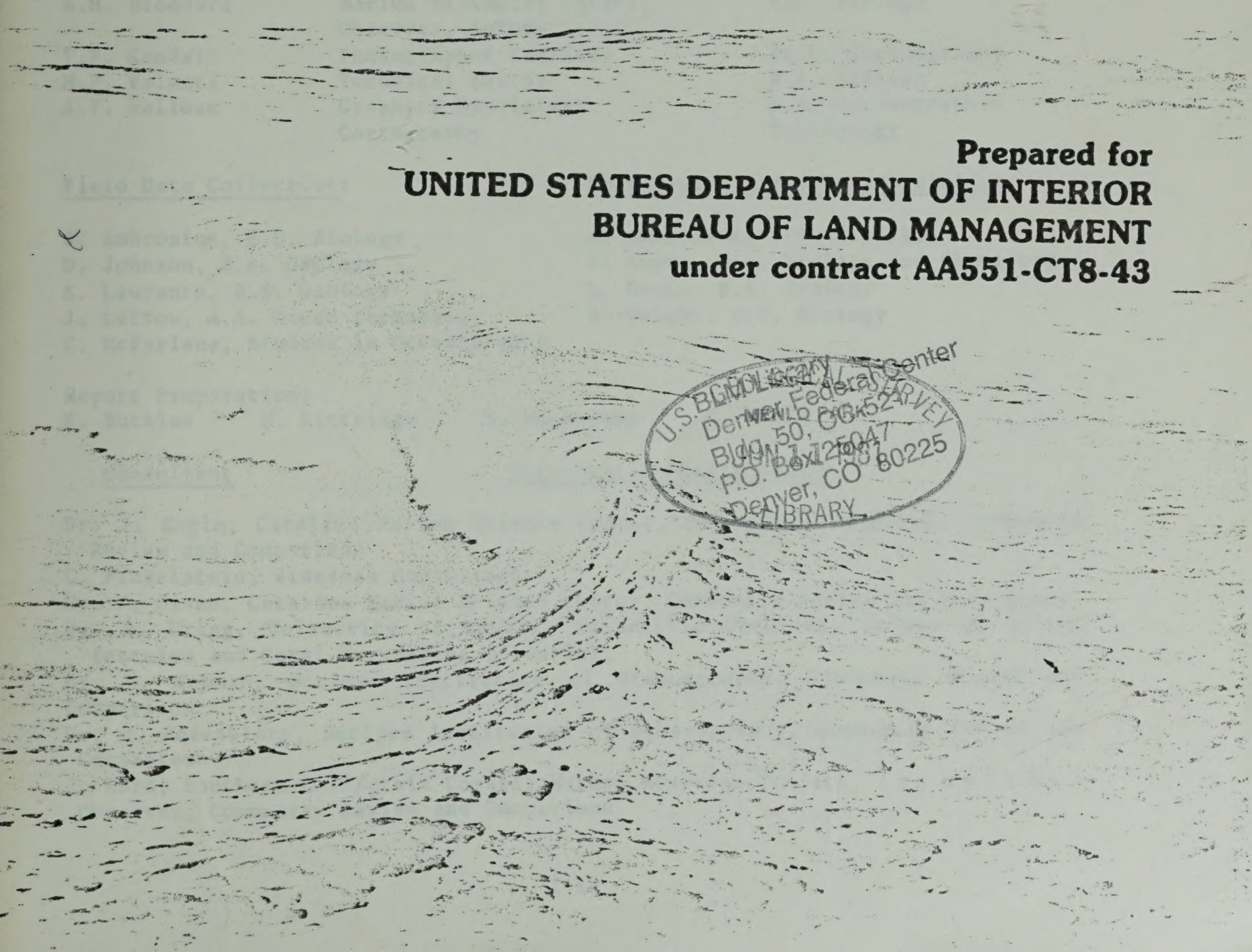
BIOLOGICAL AND GEOLOGICAL RECONNAISSANCE AND CHARACTERIZATION SURVEY OF THE TANNER AND CORTES BANKS



**Prepared for
UNITED STATES DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
under contract AA551-CT8-43**

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VOLUME I

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Volume I
EXECUTIVE SUMMARY

BIOLOGICAL AND GEOLOGICAL RECONNAISSANCE AND CHARACTERIZATION SURVEY OF THE TANNER AND CORTES BANKS

This study was supported by the Bureau of Land Management, Department of the Interior under contract AA551-CT8-43

SEPTEMBER 1979

This report has been reviewed by the Bureau of Land Management and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Bureau, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

Prepared by

OCEANIC ENGINEERING OPERATIONS
INTERSTATE ELECTRONICS CORPORATION

Prepared for

UNITED STATES DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
under contract AA551-CT8-43

Section 1

INTRODUCTION

The Outer Continental Shelf Lands Act of 1953 charged the Secretary of the Interior with the responsibility for administering the exploration and development of mineral resources on the Outer Continental Shelf (OCS) outside the territorial boundaries of individual states. In turn, the Secretary designated the Bureau of Land Management (BLM) as the administrative agency for leasing submerged Federal lands. NEPA requires all federal agencies to consider the effects of proposed activities on the environment. The OCS Lands Act Amendments of 1978 and the code of federal regulations (CFR) indicate that the principal objective of BLM's studies program is to "...establish information needed for prediction, assessment, and management of impacts on the human, marine, and coastal environments of the OCS and nearshore areas which may be affected by oil and gas activities in such area or region" (Federal Register 43:3893, January 27, 1978; 43 CFR part 3301.7). Also, in the interest of protecting and conserving our coral reef resources, the Secretary of Interior placed additional management responsibilities on BLM by issuing Secretarial Order 2978, "Outer Continental Shelf Protection of Coral Reefs." This order requires that the BLM prepare rules and regulations governing the protection and conservation of coral reefs on the OCS.

The Department of Interior initiated an environmental studies program with baseline studies in the Southern California Bight, including the Tanner and Cortes Banks area, in 1975 to meet the BLM responsibilities under the above-noted authorities prior to any exploration for oil and gas and coral harvesting on Tanner and Cortes Banks. These studies were to provide information on the status of the environment upon which predictions of the impacts of exploration and development can be based.

Tanner and Cortes Banks, two of the westernmost topographic highs in the Basin and Ridge province typical of the southern California offshore area, are located approximately 150 km (80 nmi) southwest of Los Angeles (Figure I-1). Although previous studies have provided BLM with useful information about the marine environment the overall composition and extent of the biological communities occurring on and around the shallow rocky bottom outcrops on Tanner and Cortes Banks was largely unknown prior to this study. The seven areas of high relief (labeled A through G, Figure I-1) were chosen by BLM for further study under this contract on the basis of previous mapping (Green et al., 1975).

The primary objective of this "Biological and Geological Reconnaissance and Characterization Survey" was to observe and map the distribution, composition, and relative abundance of the dominant benthic biological communities found on and around five rocky outcrop areas on Tanner and Cortes Banks, and two rocky outcrop areas in deeper waters adjacent to the Banks and on the Santa Rosa-Cortes Ridge.

This primary objective was fully met. Thus, the geological reconnaissance survey provided a broad overview of the topography and delineated the extent of rocky outcrops as well as areas of sediment accumulation. Using the

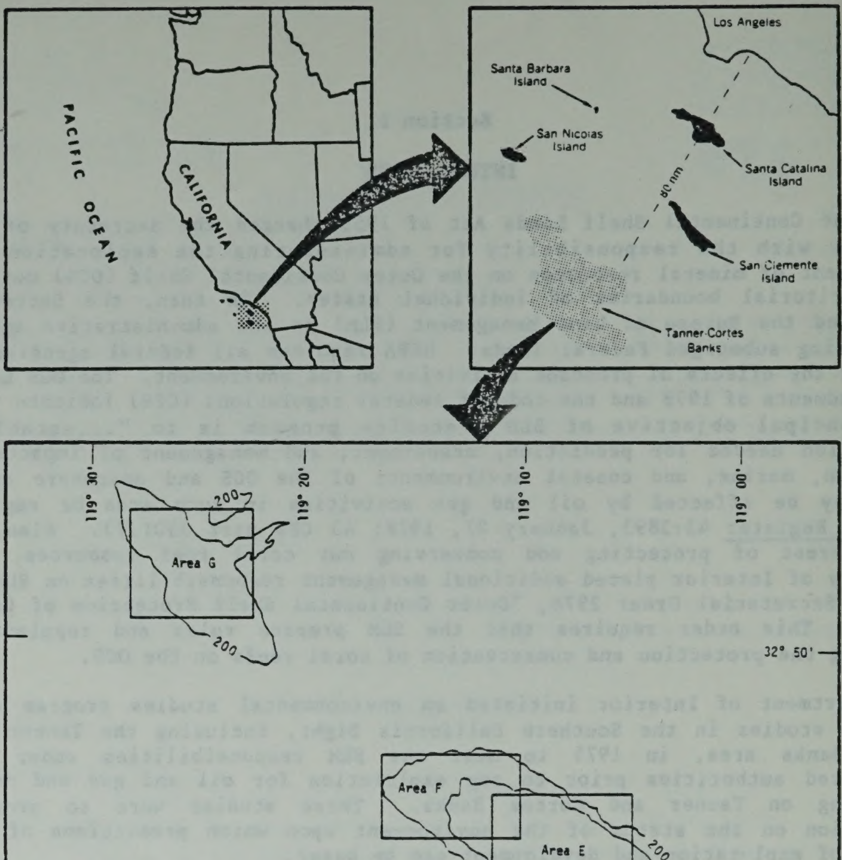

Figure I-1. Location Map of Tanner and Cortes Banks and the Study Areas A-G

precision bathymetric and side scan sonar records maps were constructed for each of the seven shallow bank top areas. In addition, specific geological objectives accomplished for each of the seven study areas were the preparation of:

- Two original detailed bathymetric maps at a scale of 1:12,000.
- Two overlay maps of the extent of the rocky outcrops, areas of sediment accumulation, and visible geological features.
- Two overlays displaying the lease block grid and the bathymetric and side scan sonar transects.
- A scientific report discussing important observed salient geologic and geomorphic trends.

The biological reconnaissance survey provided an extensive volume of quality data that was used to prepare overlay maps and a scientific report. The biological objectives were accomplished as follows:

- Performed a biological reconnaissance and characterization survey using photography and a scientific observer in a manned submersible.
- Mapped the communities of five priority areas of rocky outcrops less than 60 m depth: Bishop Rock, Nine Fathom Reef, Central Tanner Bank, Northwest Tanner Bank and Northwest Cortes Bank and one area of lower priority, Santa Rosa Ridge.
- Surveyed and mapped areas of rocky habitat between 60 and 150 m depth in the six areas of study.
- Evaluated the distribution and abundance of the Hydrocoral *Allopora californica* relative to proposed harvesting.
- Studied coral, resident fish, macroalgae distribution, and defined and mapped community associations.
- Compared the methods and results of the present study with historical data sources.
- Prepared a report, discussing observations, findings, comparisons and conclusions for each of the study areas.

The objectives of this program were achieved by performing comprehensive field surveys and data analysis. Ships and submersibles carrying scientific observers using precise navigation were used to gather extensive quantities of bathymetric, sidescan sonar, photographic, audio, video and scientist/observer records. This material will assist BLM in preparing future environmental impact statements; making management decisions regarding tract selection for lease sales; adopting special lease stipulations to mitigate potential adverse impacts from exploratory and development activity; selecting pipeline corridors (if development and production proceeds); and analyzing pending applications to harvest coral. Furthermore, this study's results could provides a basis for future monitoring studies of Tanner and Cortes Banks.

All of these objectives and results are fully discussed and documented in Volume II and summarized in the remaining sections of this volume.

VOLUME I

Section 2

FIELD AND ANALYTICAL METHODS

2.1 GEOLOGY

The Phase I survey was designed to map, selected shallow regions of Tanner and Cortes Banks where rocky outcrops were anticipated using bathymetric soundings and side scan sonography. The data were used to generate detailed bathymetric and geomorphic maps and to aid in the selection of submersible transects for the biological reconnaissance surveys.

Field surveys were conducted from Sept. 18 to Oct. 1, 1978 with the University of Southern California research vessel R/V VELERO IV. Navigation Services, Inc. used the ARGO calibrated by a Mini Ranger System for precise navigation. Bathymetric data recording on 200 and 300 m track line spacing was started with a Hydrocarta automated system and completed with standard, manual methods using an EDO fathometer along with a bathymetric Klein 400 Series side scan system. This allowed the collection of excellent sea-floor records along with the bathymetric soundings.

After all soundings were plotted, they were contoured by hand at a 2-meter interval to a depth of 100 m and at a 5 m interval for depths exceeding 100 m. Maximum and minimum depths were noted on peaks and low areas. Both relative relief and discernible lithologic rock types were used to define the geomorphic signatures, which were then mapped. All maps were initially drafted at the 1:6,000 working scale then reduced to the 1:12,000 deliverable scale.

The final products of the bathymetric and geological phases of the project are a base bathymetric map and two overlays for each study area. Plate 404-1 (base maps 1-7) depicts detailed bathymetric interpretations for each of the BLM study areas (Figure I-1). Plates 404-2 and 404-3 which are overlain over these mounted base maps show shotpoint locations of navigation fixes and geomorphic interpretations, respectively, of each of the seven areas.

2.2 BIOLOGY

The Phase II biological reconnaissance surveys were designed to obtain maximum and diverse coverage of the selected shallow water, rock bottom regions of the banks. A detailed cruise plan was written in order to properly define the responsibilities of the participants and the transects to be studied. Previous significant studies of the fish, invertebrates, and algae of the Southern California Bight providing data pertinent to the survey area, are listed and discussed in Volume II section 4. The biological reconnaissance surveys were conducted between October 20 and November 19, 1978.

All of the equipment was tested in the electronics laboratory and work shop, and at dockside during mobilization. Test dives were conducted off San Diego on October 19, and on November 3, to ensure that all systems were functioning properly while the submersible was underway.

The support vessel SEAMARK and NEKTON GAMMA, a two-man submersible used for the biological observation, were operated by Nekton, Inc. Typically, the submersible traveled as close to the bottom as was practical along the preplanned transect line at speeds varying from 0.1 to as much as 2.4 knots. The submersible's course and position were recorded by taking frequent ranges and bearings on a towed, surface marker buoy at the same time as navigational fixes were taken by the surface suppport ship to establish its position.

Data collected included automatic bottom photographs, observer photographs of specific features, black-and-white video of the sea floor, a tape recorded description of the community structure observed and organisms sighted and three 16mm movies of selected areas. Other observations associated with size and density of organisms, topography and bottom type were also recorded.

During the first cruise 21 dives covering 53,400 m (29.4 nmi) of seafloor transects were accomplished and during the second cruise 41,850 meters (22.6 nmi) of seafloor transects were accomplished in 16 dives and 4 movie dives.

As soon as possible following a dive each observer transcribed his own audio tapes into a log book. In the office, observations and photographs were divided into one-minute time intervals to facilitate coordination of the records, and the submersible positioning data.

The pictures taken by the automated Benthos camera for each dive were examined, frame by frame, by a team of observers. Data was recorded quantitatively whenever possible, as number of individuals or percent cover from correctly-exposed slides. Hand-held photographs were used to record unusual or characteristic species and assemblages.

Overall, the highest-quality observations were made by the scientific observer. Video was primarily useful for evaluating the large macroalgae cover, fish population densities, and substrate, whereas the automated Benthos camera records were more useful in identifying and quantifying smaller macroalgae and invertebrate populations.

Data recorded by observers, and that derived from the video and Benthos cameras were entered into the computer. Thirty-one species categories were selected for density and distribution analysis on the basis of adequacy of identification and frequency of observation.

The community dominants described in the present study Volume II section 4 are based largely on the judgment of the biological observer team, including scientific consultants and BLM representatives, and were verified by a review of observer, video, and photographic records.

The community structure of the Banks was determined by:

- o Density vs depth analyses for the dominant and subdominant species.
- o Comparing and contrasting density curves for different species in each area and for the six areas combined, to detect any consistent species assemblages.

- Considering depth and substrate types to resolve discrepancies and clarify community zonation.

Persistent species assemblages were recorded along the transect lines superimposed on the bathymetric and geomorphological maps. The numbers per square meter, percent coverage, and organism sizes were noted for dominant fish, algae, and coral populations. From this data the final overlay maps for benthic communities (Plate 404-5), fish distribution (Plate 404-6) and *Allopora* distribution (Plate 404-7) were compiled.

Volume I

Section 3

RESULTS AND DISCUSSION

3.1 GEOLOGY

Tanner and Cortes Banks are located on a persistent ridge at the western edge of the Southern California Continental Borderland, 150 km off the California Coast. Discontinuous northerly trending folds and faults control the local geologic structure. The Banks and Santa Rosa Ridge rise more than 2,000 m above adjacent submarine basins and are composed primarily of miocene basalt and undifferentiated miocene sedimentary and igneous rocks (Vedder et al., 1974). The shallowest water depth, at Bishop Rock on Cortes Bank, is only 4 m. The two banks are connected by a shallow saddle, and have a total area of approximately 700 sq. km.

The bathymetric and side scan survey was limited to the areas of the bank tops suspected to have high relief rock outcrops. In general the rock outcrop areas as mapped by Greene et al. (1975) conformed to those mapped in the present study. Figure I-2 depicts the areas of the bathymetric and side scan sonar survey for the present study.

Interstate Electronics' geological reconnaissance survey involved data gathering techniques which are an order of magnitude more detailed than previous investigations, using side scan sonar and precisely positioned echo soundings that were supplemented with submersible photographs and observations.

The primary areas were surveyed with a trackline spacing of 200 m. Tracklines were terminated when surface sediments were encountered, usually near the break in slope, and where the bottom was smooth. A reduced bathymetric map of Tanner Bank (Area E) with a 10 m contour interval is shown as Figure I-3. The comprehensive, full sized maps contoured at 2 m intervals have been mounted on foam core board and accompany Volume II of this report as Plate I, Maps 1 to 7. A typical cross section of the Banks (Area E) is shown as Figure I-3.

Seven different generalized signatures (patterns) were observed in the side scan records. In general, each signature is related to a combination of topographic relief and bedrock lithology. A reduced geomorphic map of Area E is shown as an example (Figure I-4). The seven study areas are briefly discussed below; however, a full understanding requires references to the main report in Volume II, and the maps and overlays Plate 401-3, Maps 1 to 7.

Cortes Bank is composed of three study areas, A, B, and C, (Figure I-1). Refer to Volume II and Plates 404-1 and 404-3, maps number 1, 2, and 3 for additional information. High relief igneous rocks make up the central portion of both Area A & B and appear to be surrounded by undifferentiated igneous and sedimentary rocks. The wave cut platforms, protected areas, and areas in between rock ridges, are typically covered by surficial sediments. The

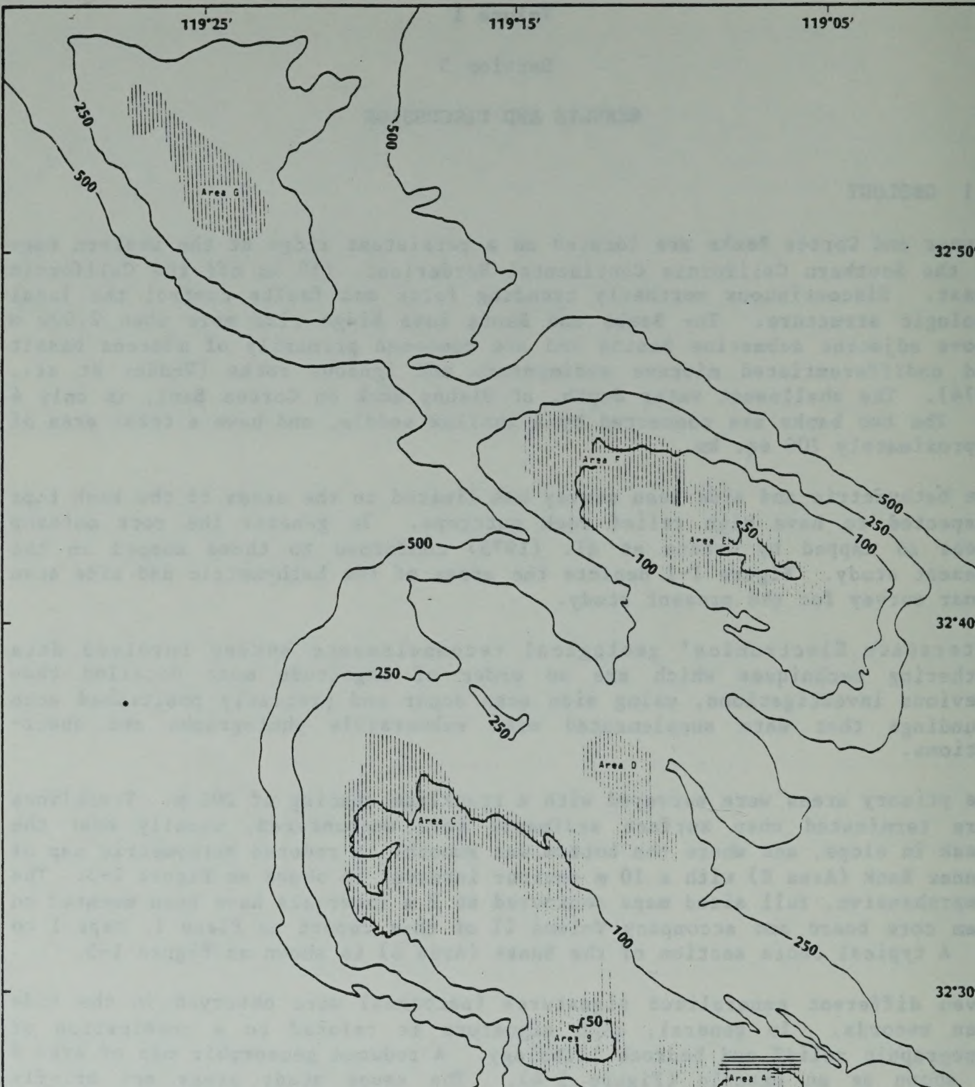

Figure I-2. Bathymetric and Side Scan Sonar Survey Areas

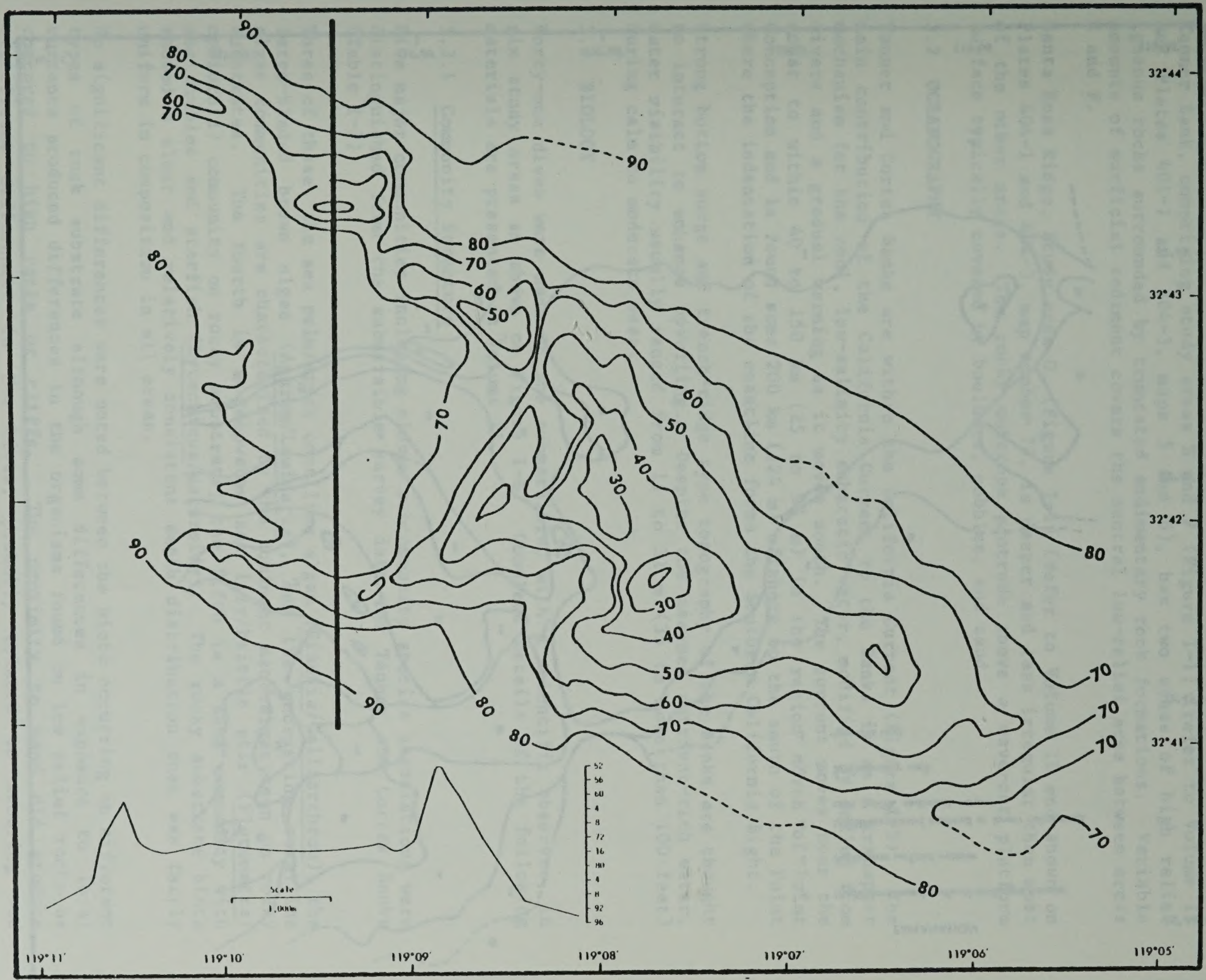

Figure I-3. Bathymetry and Cross-Section Tanner Bank (Area E)

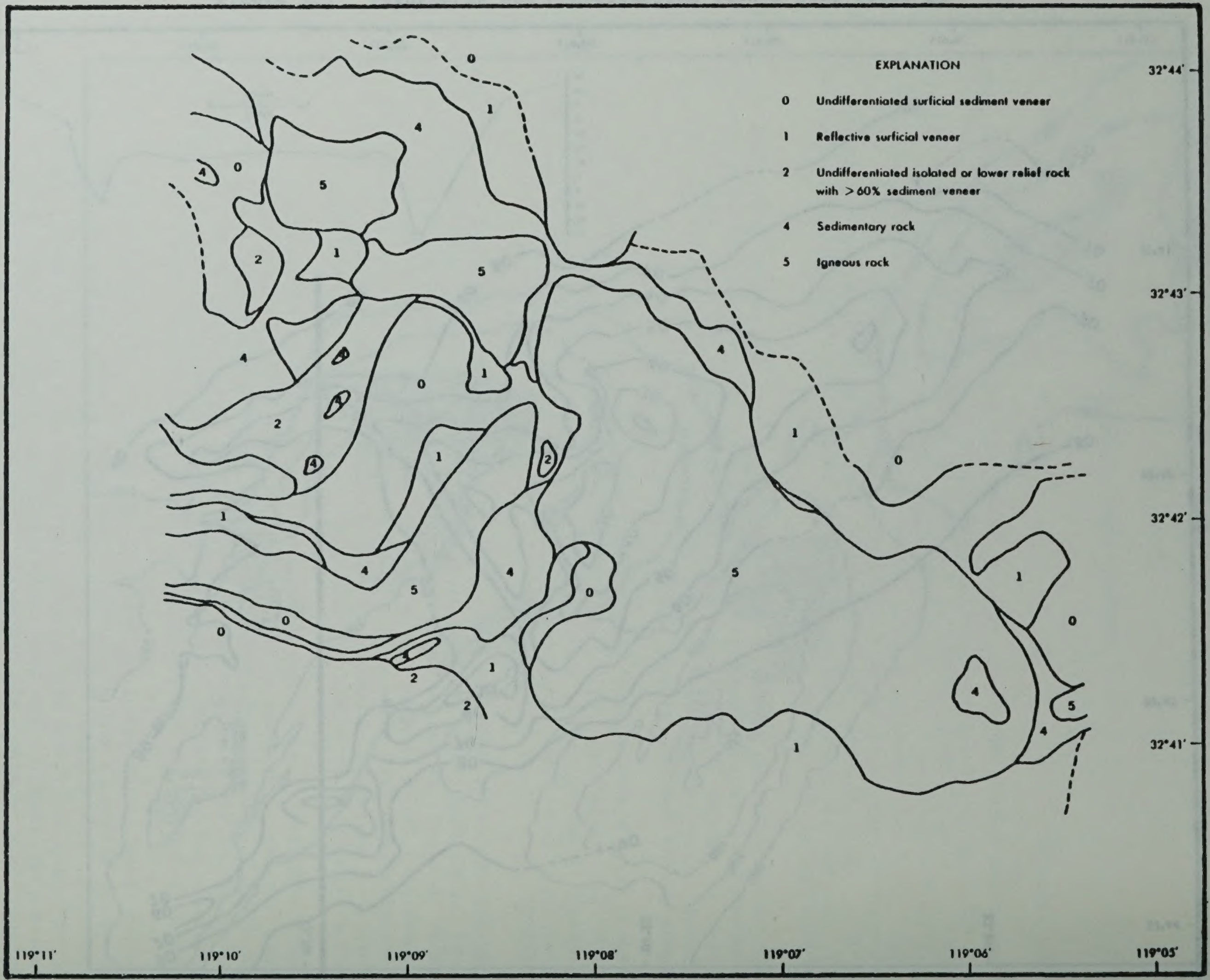
EXPLANATION
0 Undifferentiated surficial sediment veneer
1 Reflective surficial veneer
2 Undifferentiated isolated or lower relief rock with >60% sediment veneer
4 Sedimentary rock
5 Igneous rock
32°44'
32°43'
32°42'
32°41'
119°11'
119°10'
119°09'
119°08'
119°07'
119°06'
119°05'

Figure I-4. Reconnaissance Geology and Geomorphology of Tanner Bank (Area E)

Tanner Bank, comprising study areas E and F (Figure I-1) (refer to Volume II and Plates 401-1 and 404-3, maps 5 and 6), has two areas of high relief igneous rocks surrounded by truncated sedimentary rock formations. Variable amounts of surficial sediment covers the central low-relief area between areas E and F.

Santa Rosa Ridge, Study area G, (Figure I-1) (refer to Volume II and shown on Plates 404-1 and 404-3, map number 7), is deeper and less irregular than most of the other areas. The rocky outcrops protrude above a wave-cut platform surface typically covered by boulders, cobbles, and sand.

3.2 OCEANOGRAPHY

Tanner and Cortes Banks are within the California Current (Figure I-5). The main contribution of the California Current to the Banks is as a transport mechanism for the cool, low-salinity subarctic water, modified by influx from rivers and a gradual warming as it moves south. The current moves near the coast to within 40 to 150 km (25 to 93 m) in the region north of Point Conception and is found some 200 km (124 m) offshore to the south of the Point where the indentation of the coastline forms the Southern California Bight.

Strong bottom surge and trench-ridge type topography of the Banks are thought to interact to enhance upwelling. Despite the assumed nutrient-rich water, water visibility usually ranged from 11 to 31 m (35 to more than 100 feet) during calm to moderate seas.

3.3 BIOLOGY

Forty-one dives were made in the submersible, with a scientific observer, in six study areas as shown on Figure I-6. Complete details of the following materials are presented in Volume II.

3.3.1 Community Structure

Five major communities including eleven subcommunity species associations were distinguished from the submersible survey data for Tanner and Cortes Banks (Table I-1).

Three of these, the sea palm/erect coralline algae (Eisenia/Calliarthron), the large-bladed brown algae (Agarum/Laminaria), and the encrusting coralline algae communities are characterized by the dominant macroalgae seen on rocky substrates. The fourth is a deepwater sea lily/brittle star (Florometra/ ophiuroid) community on rocky substrate; the fifth is a sand community with sea urchins and starfish (Lytechinus/asteroids). The rocky substrate biota showed a clear and relatively consistent depth distribution that was fairly uniform in composition in all areas.

No significant differences were noted between the biota occurring on different types of rock substrate although some differences in exposure to local currents produced differences in the organisms found on low relief rocks as compared to high rocks or cliffs. The proximity to sand did produce significant differences in the biota, probably related to scouring and burial.

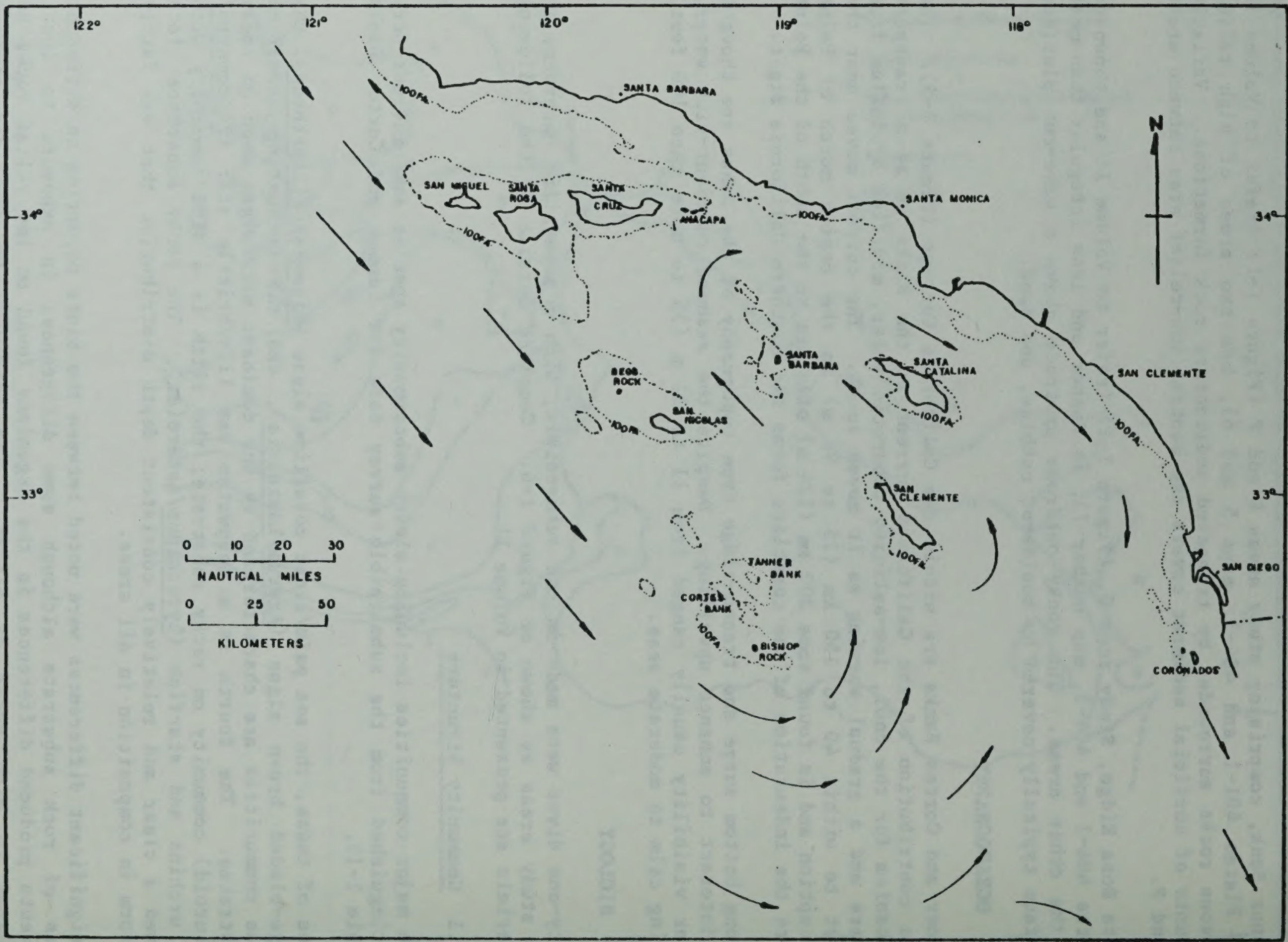

Figure I-5. Surface Circulation to 100-meter Depth in Southern California Bight. Arrows Indicate Approximate Direction of Flow (Source: Jones, 1971)

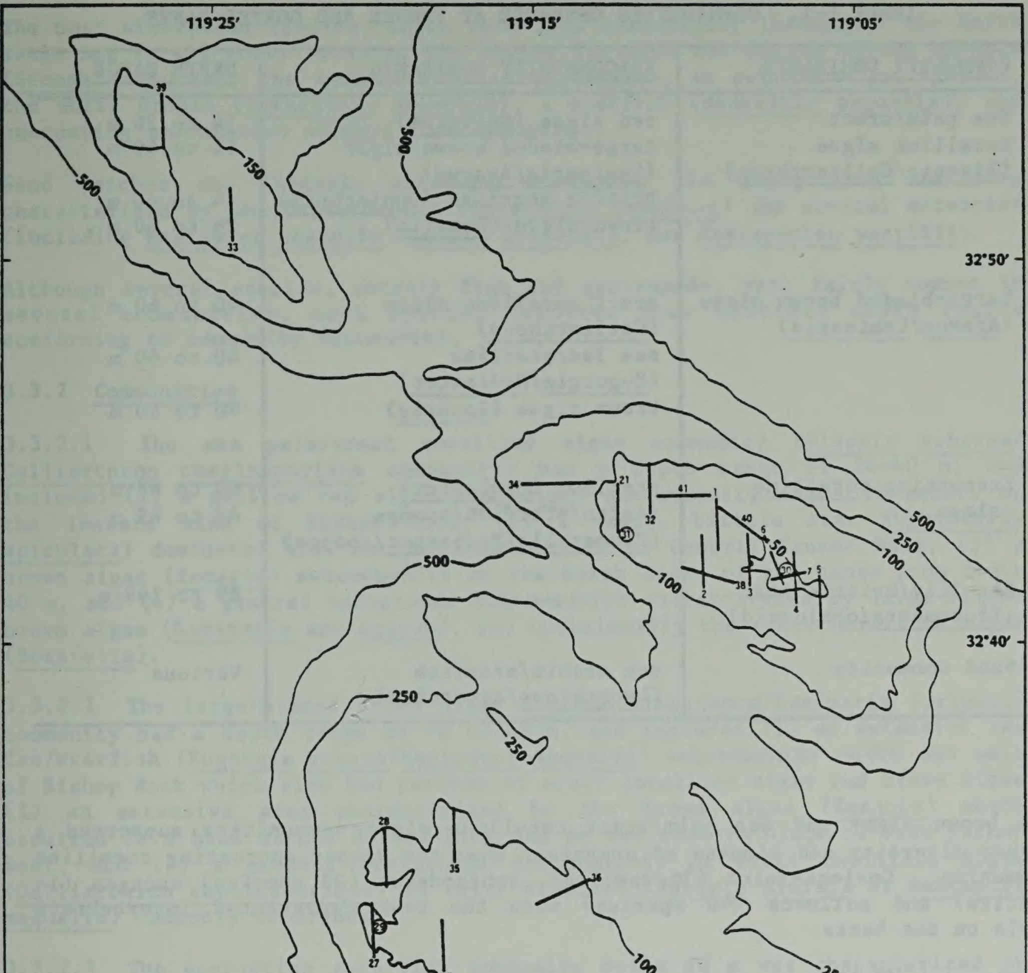

Figure I-6. Submersible Survey Transect Coverage

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TABLE I-1. COMMINUTIES OBSERVED AT TANNER AND CORTES BANKS

COMMUNITY DOMINANTS	SUBCOMMUNITY DOMINANTS	DEPTH RANGE
Sea palm/erect coralline algae (Eisenia/Calliarthron)	red algae (Gelidium)	14 to 26 m
	large-bladed brown algae (Laminaria/Agarum)	14 to 40 m
	brittle starfish (Ophiothrix)	14 to 40 m
	brown algae (Zonaria)	26 to 40 m
Large-bladed brown algae (Agarum/Laminaria)	erect coralline algae (Calliarthron)	40 to 60 m
	sea fan/starfish (Eugorgia/Mediaster)	40 to 60 m
	brown algae (Zonaria)	40 to 60 m
Encrusting coralline algae	starfish (Mediaster)	60 to 68 m
	seafan/starfish/sponge (Plumarella/Mediaster/sponge)	68 to 89 m
Sea lily/brittle star (Florometra/ophiuroid)		89 to 149 m
Sand Community	sea urchin/starfish (Lytechinus/asteroids)	Various

The brown algae and sea palm/erect coralline algae communities supported a higher diversity and biomass of organisms than the deeper encrusting coralline community. Coelenterates (36 species), echinoderms (38 species) sponges (14 species) and molluscs (40 species) were the best represented invertebrate phyla on the banks.

Crustaceans (lobsters, crabs, and shrimp) were rarely observed due to their cryptic or nocturnal habits and small size. Shrimp were much more visible in the evening than during daylight hours. Essentially all crustacea observed, were seen in medium to high relief areas where ledges, cracks, and crevices were numerous and extensive. A few crabs were seen on open sand. It is likely that crustacean biomass is considerably larger in the Banks area than was observed because they are preferred food items for many fish (Quast, 1968); and the fish population was considered to be large.

Forty species of molluscs were observed in the study area; however, only six species could be considered common (Calliostoma annulatum, Tegula regina, Astraea gibberosa, Acmaea funiculata, Nassarius insculptus, and Cidarina cidaris). Several unusual snails were seen, including Fusitriton oregonensis (which has only one previous record this far south of San Nicholas Is.), Calliostoma ?turbinum, a rare or new species, and a peculiar unidentified banded snail.

The most widespread species, which were seen essentially throughout the depth range and in all rocky areas of the survey included the purple column anemone (Stomphia venosa), the anemone (Tealia piscivera), an ostrich-plume hydroid, the white urchin (Lytechinus anamesus), a starfish (Mediaster aequalis), and encrusting and massive sponges (Demospongiae).

Sand patches and channels occurred throughout the study area and were characterized by the white urchin (Lytechinus anamesus) and several asteroids (including Mediaster aequalis, Luidia foliolata, and Astropecten verrilli).

Although several species, notably fish and gastropods, were fairly common in several communities, most species occurred over discrete depth ranges conforming to community boundaries.

3.3.2 Communities

3.3.2.1 The sea palm/erect coralline algae community (Eisenia arborea/ Calliarthron cheilosporides community) had a depth range of 14-40 m, and included (1) a shallow red algae (Gelidium) subcommunity above 26 meters on the leeward side of Bishop Rock, (2) a small, brittle star (Ophiothrix spiculata) dominated area on the leeward side of Central Tanner Bank, (3) a brown algae (Zonaria) subcommunity on the north sides of the banks from 26 to 40 m, and (4) a general background subcommunity characterized by large-bladed brown algae (Laminaria and Agarum), and occasionally the erect coralline algae (Bossiella).

3.3.2.2 The large-bladed brown algae (Agarum fimbriatum/Laminaria farlowii) community had a depth range of 40 to 60 m, and included (1) an extensive sea fan/starfish (Eugorgia rubens/Mediaster aequalis) subcommunity north and west of Bishop Rock which also had patches of erect coralline algae and brown algae (2) an extensive area characterized by the brown algae (Zonaria) which occurred in a band across Bishop Rock and on the eastern slope of Nine Fathom Reef, and (3) a general background subcommunity of erect coralline algae (Calliarthron cheilosporides) in which starfish (Patiria miniata or Mediaster aequalis) commonly occurred.

3.3.2.3 The encrusting coralline community below 60 m was characterized by the presence of variously colored crusts (algae, bryozoans, sponges, tunicates), the calcareous tube worm (Protula superba), brachiopods (Laqueus and Terebratalia), a "snowflake" bryozoan, a sea anemone (Stomphia coccinea), a hydroid (Abietinaria), and the purple top shell (Calliostoma annulatum). Distinct depth-limited subcommunities included (1) the starfish (Mediaster aequalis) subcommunity from 60-68 m depth with scattered vase sponges ("Staurocalyptus") and calcareous bath sponges ("Clathrina") and (2) the sea fan/starfish/sponge (Plumarella longispina/Mediaster aequalis/sponge ["Staurocalyptus" and "Clathrina"]) subcommunity from 68 to 89 m, which also included most of the colonial anemones (Corynactis californica) and various corals such as Allopora californica, Coenocyathus bowersi, Paracyathus stearnsi and Balanophyllia elegans.

3.3.2.4 The sea lily/brittle star (Florometra serratissima/ophiuroid) subcommunity occurred below 89 m, primarily on Santa Rosa Ridge.

3.3.2.5 The sand community was composed mostly of white sea urchins and starfish (Lytechinus/Mediaster) and occurred in patches and channels at all depths but was more widespread at depths below 60 m.

3.3.3 Area Descriptions

Differences in community structure between the six areas surveyed were primarily due to differences in depth. However, several unique species associations and shifts in community boundaries to shallower or deeper depths were observed which were probably related to sand scour and exposure. Currents produce a northwest-southeast trend on the banks which fish, macroalgae and invertebrate populations tend to follow. In general, the rocky, boulder, cobble portions of the western and southwestern sides of the banks were the most diverse (greatest relative number of species), and supported the densest (greatest relative number of individuals) populations of Allopora, stony corals, fan corals, and associated species. An example of a benthic community map is presented for Tanner Bank (Area E) as Figure I-7.

In general, the senorita fish tended to reach a maximum population density on the southeast side, while the squarespot rockfish population centered on the northwest side of each bank. Senorita were found primarily over high relief rocks, whereas the squarespots tended to occur over both high and low relief rocks.

Bishop Rock (Area A) is dominated by a sea palm (Eisenia) community above 40 m and a large-bladed brown algae (Agarum/Laminaria) community from 40 to 60 m depth. Two unique subcommunities were found: the sea fan/starfish (Eugorgia/Mediaster) subcommunity to the northwest, which included much of the Allopora of the bank, and the red algae (Gelidium) subcommunity to the southeast. The encrusting coralline community below 60 m depth was poorly developed due to the presence of extensive sand areas at that depth.

Nine Fathom Reef (Area B) is dominated by the sea palm (Eisenia) community above 40 m depth with relatively sparse occurrences of the erect coralline algae Calliarthron. Allopora was found primarily in this community above 40 m depth and it was more limited on the eastern slope, extending to only 30 m depth. On the north and west sides of the bank Allopora extended to 62 m depth. The large-bladed brown algae (Agarum/Laminaria) community was observed from 40 to 68 m depth with encrusting coralline algae occurring below that.

Northwest Cortes (Area C) is characterized by a fairly uniform encrusting coralline community which was expected to be common because of the deeper depths surveyed (60 to 123 m) relative to areas A,B,E, and F. This area had an extension of the starfish (Mediaster) subcommunity from 89 to 94 m on the north slope of the southern rises, and a possible transition zone into a large-bladed brown algae (Agarum/Laminaria) community above 74 m on the western bank. Allopora reached its deepest extreme on this bank, occurring from 80 to 123 m in the sea fan/starfish/sponge (Plumarella/Mediaster/sponge) subcommunity.

Central Tanner (Area E) has only scattered areas of the sea palm (Eisenia) above 40 m depth, and was dominated by the large-bladed brown algae (Agarum/Laminaria) community between 40 to 60 m. This area had unique areas

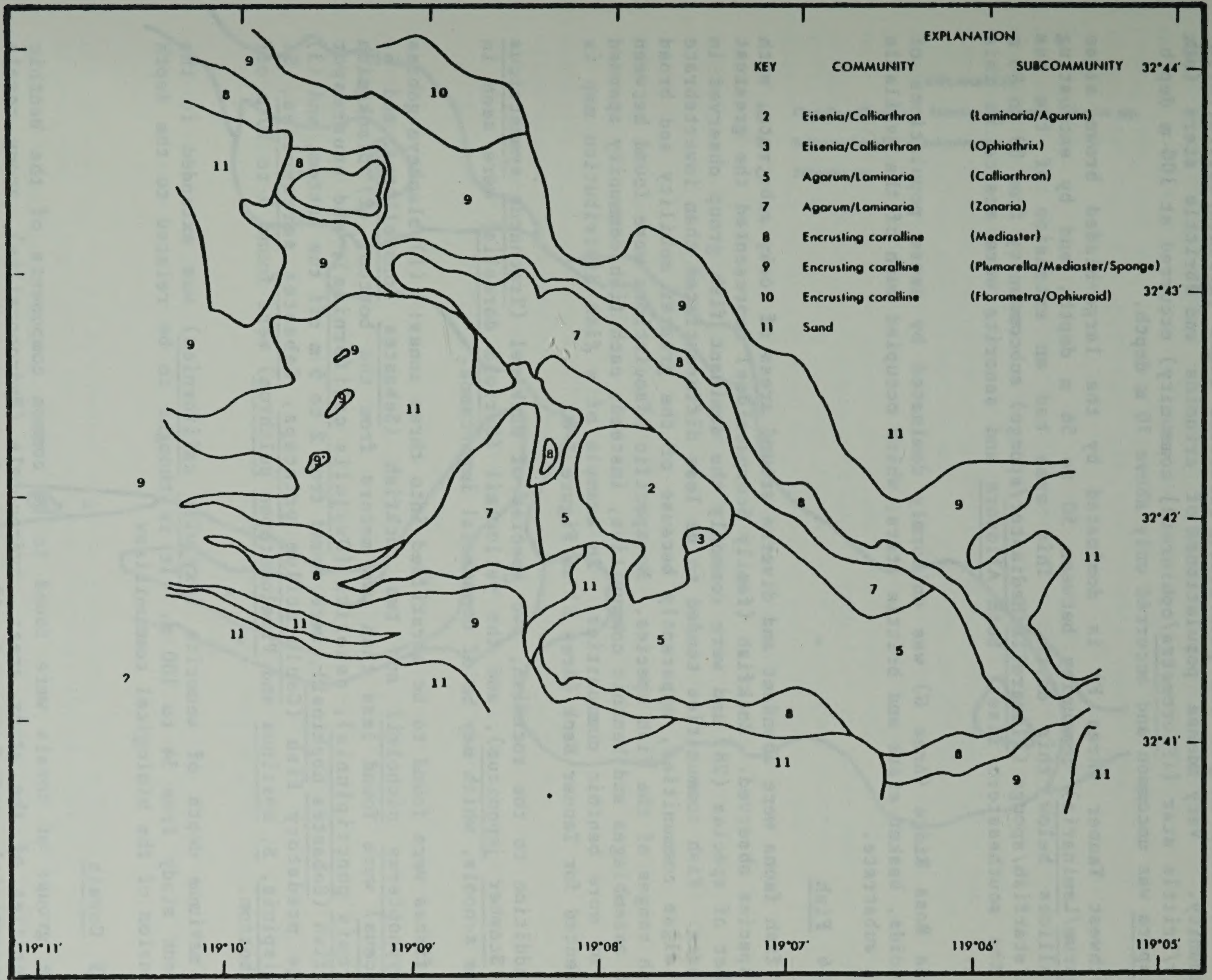
EXPLANATION
KEY COMMUNITY SUBCOMMUNITY
2 Eisenia/Calliarthron (Laminaria/Agarum)
3 Eisenia/Calliarthron (Ophiothrix)
5 Agarum/Laminaria (Calliarthron)
7 Agarum/Laminaria (Zonaria)
8 Encrusting corralline (Mediaster)
9 Encrusting coralline (Plumarella/Mediaster/Sponge)
10 Encrusting coralline (Florometra/Ophiuroid)
11 Sand
32°44'
32°43'
32°42'
32°41'
119°11'
119°10'
119°09'
119°08'
119°07'
119°06'
119°05'
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Figure I-7. Benthic Community Map Tanner Bank (Area E)

dominated by brittle star (*Ophiothrix spiculata*) at 40 m depth on the southeast side in the sea palm/erect coralline algae (*Eisenia*/*Calliarthron*) community. Very dense populations of crinoids and brittle stars (sea lily/brittle star [(*Florometra*/ophiuroid] community) occurred at 100 m depth. *Allopora* was uncommon and occurred only above 70 m depth.

Northwest Tanner (Area F) is dominated by the large-bladed brown algae (*Agarum*/*Laminaria*) community between 50 to 56 m depth, and by encrusting corallines below this depth. This area had an extension of the sea fan/starfish/sponge (*Plumarella*/*Mediaster*/sponge) subcommunity from 89 to 98 m on the southeastern rise. Both *Allopora* and senorita were scarce in this area.

Santa Rosa Ridge (Area G) was uniformly dominated by dense populations of crinoids, basket stars and brittle stars, which occupied much of the available rock substrate.

3.3.4 Fish

The fish fauna were abundant and diverse around areas of rocky substrate, with 67 species observed. Rockfish (family Scorpaenidae) represented the greatest number of species (28) and were commonly the dominant fish group observed in an area. Fish communities tended to be less differentiated than invertebrate and algae communities, apparently because of the greater mobility and broad depth ranges of the fish species. No specific associations were found between fish assemblages and benthic communities, instead, each fish community spanned two or more benthic communities. An example of a fish distribution map is presented for Tanner Bank (Area E) as Figure I-8.

In addition to the rockfish, two species of mackerel (*Trachurus symmetricus* and *Scomber japonicus*), and the yellowtail (*Seriola dorsalis*) were seen in large schools, which may be of commercial importance.

The fishes were found to be stratified into three zones: (1) blackeye gobies (*Coryphopterus nicholsi*) and two rockfish (*Sebastes constellatus* and *S. rosaceus*) were found less than two meters from the bottom, (2) blacksmith (*Chromis punctipinnis*), senorita (*Oxyjulis californica*), and squarespot rockfish (*Sebastes hopkinsi*), were found from 2 to 5 m off the bottom, and (3) large predatory fish (*Caulolatilus princeps*, *Sebastes serranoides*, *S. paucispinis*, *S. mystinus* and *Pimelometopon pulchrum*) were found 5 to 10 m off the bottom.

The maximum depth of senorita (*Oxyjulis californica*) was extended in the present study from 54 to 100 m. It is thought to be related to the depth extension of the biological communities.

3.3.5 Corals

Three groups of corals were found to be common components of the benthic communities of the study area: hydrocorals (Hydrocorallia), stony corals (Scleractinia), and fan corals (Gorgonacea). A detailed discussion is in Volume II Section 4.

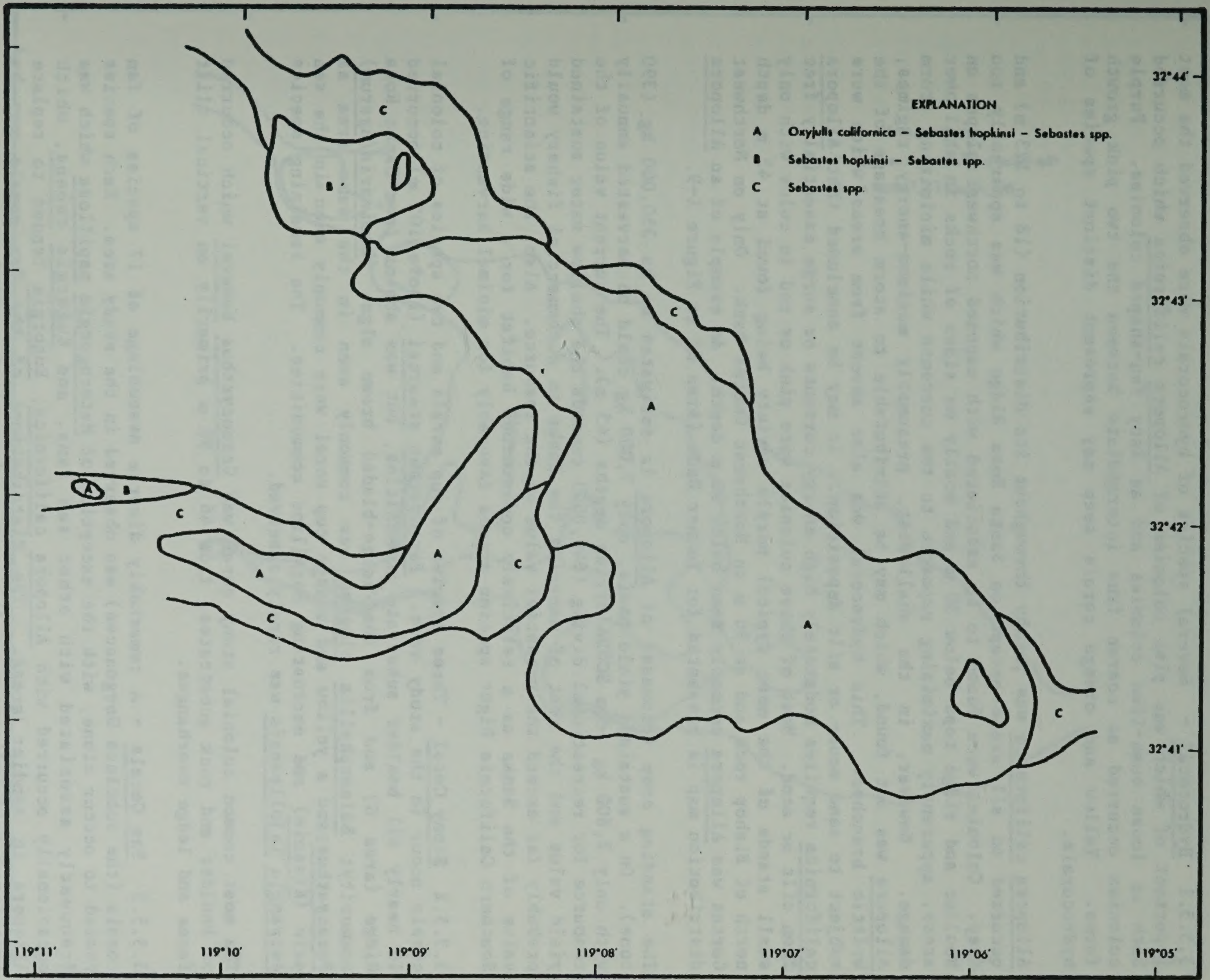

Figure I-8. Fish Distribution Map Tanner Bank (Area E)

3.3.5.1 Hydrocoral - Several species of hydrocorals were observed the most important of which was pink colonies of Allopora californica which occurred both as loose bush-like colonies and as lacy fan-shaped colonies. Purple colonies occurred as coarse fans intermediate between the two pink growth forms. Yellow and orange corals seen may represent distinct species of hydrocorals.

Allopora californica was patchy throughout its distribution (18 to 123 m) and occurred on all areas except on Santa Rosa Ridge which was apparently too deep. Colonies were found to be associated with exposed northwest slopes on boulder and ridge tops below 30 m and mostly on sides of rocks in shallower areas, apparently maximizing exposure to the currents while minimizing storm damage. However, in the shallowest, presumably maximum-energy regimes, Allopora was not found, which may be attributable to storm breakage of the brittle branches. This hydrocoral was also absent from areas which were subject to sand scour or silt deposition. It may be concluded that Allopora californica requires moderately high energy currents or surge essentially free from silt or sand. Most of these colonies were pink or red in color with only small stands of the more typical purple variety being found at 45 m depth north of Bishop rock and at 96 m on Northwest Cortes Bank. Only on Northwest Cortes was Allopora commonly seen below 70 m depth. An example of an Allopora distribution map is presented for Tanner Bank (Area E) as Figure I-9.

The standing crop (biomass) of Allopora is estimated to be 350,000 kg (390 tons). On a sustained yield basis, only 7,000 kg could be harvested annually with only 2,800 kg from SCUBA diving depths (45 m). The current value of the resource for recreational diving ($40,000) exceeds the shallow water sustained yield value and the cost of managing the Banks as a commercial fishery would probably far exceed the potential value of the resource. Also, the scientific value of the Banks as a relatively undisturbed habitat for a wide range of Southern California Bight species argues favorably for minimal harvesting.

3.3.5.2 Stony Coral - Three species of cup corals and two species of colonial corals occur in the study area. Paracyathus stearnsi (above 102 m) occurred in nearly all boulder substrate communities, but was absent from Santa Rosa Ridge (area G) and from the large-bladed brown algae (Laminaria/Agarum) community; Balanophyllia elegans was commonly seen in the same area as Paracyathus;and a yellow and orange cup coral were commonly seen in the sea palm (Eisenia) and encrusting coralline communities. The remaining species Astrangia lajollaensis was rarely observed.

The most common colonial stony coral was Coenocyathus bowersi which occurred on boulder and rock substrates, from 46 to 96 m primarily on vertical cliff faces and ledge overhanges.

3.3.5.3 Fan Corals - A remarkably diverse assemblage of 17 species of fan corals (the subclass Gorgonacea) was observed in the study area. Each species tended to occcur alone, with the exception of Heterogorgia papillosa which was frequently associated with other sea fans, and Eugorgia rubens, which occasionally occurred with Allopora californica; Eugorgia tended to replace Allopora in sandier areas. The distributions of the fan corals may be considered good indicators of divergent environmental conditions.

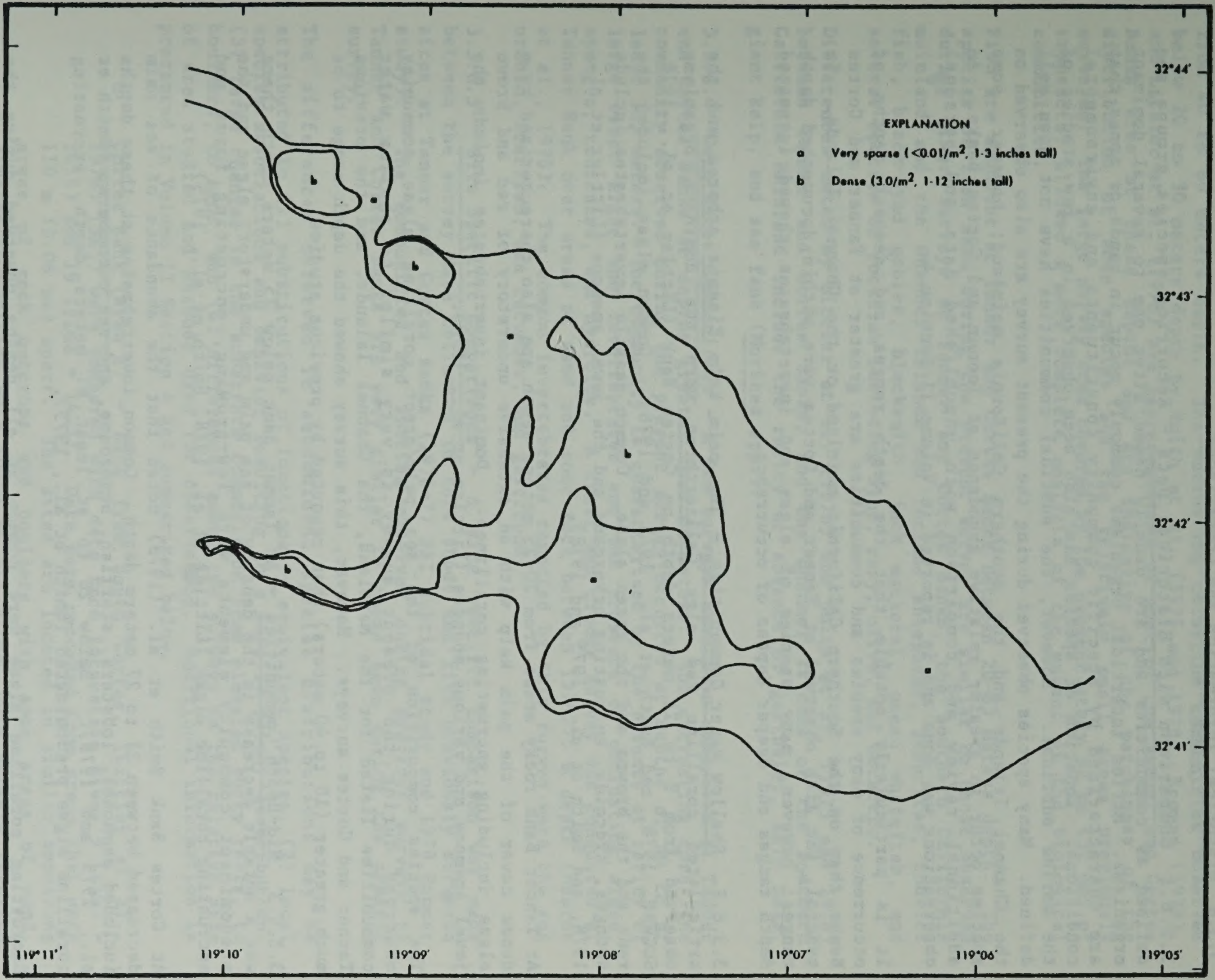

Figure I-9. Allopora Distribution Map Tanner Bank (Area E)

3.3.6 Historical Information and Comparisons

3.3.6.1 Comparison with Historical Data - Recurring species groups are defined as communities and are usually named after one to several dominant organisms. Marine intertidal organisms commonly occur in bands or zones that are characterized by specific community constituents and environmental conditions. Zonation of species has also been observed in a few studies of the marine subtidal. However, the subtidal communities have not been well defined. Many species observed during the present survey are also observed on the Channel Islands and the southern California mainland; however, some species occur in greater relative abundance at Tanner and Cortes Banks. An additional review and comparison with unpublished data and personal observations was done and is reported in Volume II Section 4.

It is particularly notable that the depth ranges and deepest depths of occurrence of many species and communities are greater at Tanner and Cortes Banks than on the Southern California mainland or the Channel Islands. In general, the fish observed at Tanner and Cortes were within documented depth ranges; however, many species of algae and invertebrates showed increased depth ranges and deeper depths of occurrence.

3.3.6.2 Shallow Water Communities - The palm kelp Eisenia arborea and the articulated coralline red alga Calliarthron were the dominant organisms observed from 9 to 21 meters depth on Cortes Bank (Littler et al., 1978, SCCWRP, 1978, and Smith et al., 1975 and 1978). Common algae included the reds and the browns and the green algae. Common sessile invertebrates include sponges, hydroids, encrusting bryozoans and the jewel anemone (Littler et al., 1978, and Smith et al., 1975 and 1978).

At Tanner Bank rocky areas from 20-25 meters depth are also characterized by a dense cover of the palm kelp with an extensive understory of red and brown algae including encrusting corallines. Dominant invertebrates include the jewel anemone and various sponges (Littler et al., 1978).

The species composition of the sea palm/erect coralline algae community observed during the present survey is very similar to shallow water communities listed for the Mainland, the Channel Islands, and the previous Tanner and Cortes surveys. However, this survey showed the depth range to be much greater (10 to 40 meters) than reported by previous studies.

3.3.6.3 Mid-Depth Communities - At Tanner Bank below 25 meters depth there was a notable decrease in the density of sea palm and understory algae and the predominant community elements were low-growing, encrusting forms and encrusting coralline algae (Littler et al, 1978, Smith et al., 1975).

At Cortes Bank Smith et al. (1978) noted that the abundance of sea palm decreased between 21 to 27 meters depth. Common invertebrates at these depths included anemones, lobsters, starfish, bryozoans, and sea cucumbers, (Smith et al., 1975 and 1978). Below 26 to at least 61 meters depth, encrusting coralline algae predominated (Smith et al., 1975).

Encrusting coralline algae were common at all depths observed during the present survey but macroalgae were also common to at least 60 meters depth. The present survey showed that a large-bladed brown algae community occurred

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from 40 to 60 meters depth. The encrusting coralline communities observed below 20 to 30 meters depth by Smith et al. (1975 and 1978), Ecomar (1978), and Littler et al. (1978) are representative of most of the Tanner and Cortes Banks area at these depths and are indicative of the patchiness of the distribution of some species and the relatively small areas previously surveyed. The large survey area covered by the present study 92 km (52 nmi of transects) allowed a more complete analysis of the extent of the biological communities.

Fish are abundant at Tanner and Cortes Banks between 20-63 meters depth. The species of fish seen during the present survey are similar to those observed during other surveys at Tanner and Cortes Banks, the southern California mainland and the Channel Islands and include sheephead, senoritas, convict fish, black-eyed gobies, blacksmith, jack mackerel, ocean whitefish, and several species of rockfish including blue, rosy, olive, and bocaccio.

Differences noted by Littler et al. (1978) and Smith et al. (1975 and 1978) between Tanner and Cortes Banks, and the Channel Islands or the Southern California Mainland include the rarity or absence of garibaldi, kelp bass, giant kelp, and sea fans (Muricea spp.).

3.3.6.4 Deep Water Communities - A few surveys have been conducted at Tanner and Cortes Banks at depths greater than 60 meters. The encrusting coralline community observed during the present survey occurred at depths of 60 to at least 125 meters. The community is characterized by the absence or rarity of large erect algae and invertebrates and the presence of encrusting algae, sponges, tunicates, and hydroids. A trawl and dredge survey was conducted at Tanner Bank over areas of sand and some rock between 137-275 m depth (Mearns et al., 1978). The common invertebrates reported by this survey were the sea urchin, starfish, sea cucumber, and gastropod.

3.3.6.5 Site Specific Comparisons - A site specific comparison was made between the survey data collected in this study and five previously surveyed sites at Tanner and Cortes Banks (1976-77 SAI subtidal study and 1978 Ecomar study). The communities and species observed during previous surveys of Tanner and Cortes Banks are very similar to those seen during the present survey.

The differences observed in subdominant species distributions may be attributed to (1) substitutions of functionally equivalent species, (2) local species associations and behavior resulting in a locally patchy distribution, (3) large changes in the substrate composition from elevated rocky reefs, to boulders, to sand, and (4) differences among the surveys in the relative size of area studied and methods used for observation. Additional information is presented in Volume II Section 4 and summarized below.

o Cortes Bank (Area A) - Data from South Cortes, (Littler et al., 1978) (SAI) were compared with data from Interstate dives 9 (time = 1415) and 19 (time = 1425). Data were recorded from areas that were 110 m (0.06 nm) apart. The sites are located in similar appearing areas of rock outcrops and boulders with some areas of sand. Similar communities were found at all sites: both surveys reported that the dominant macroalgae was Eisenia, encrusting coralline algae, and Calliarthron. The algae Gelidium, Zonaria, Dictyota/Pachydictyon, Corallina, Cystoseira, and Codium sp. (encrusting) were recorded by both surveys, although Gelidium Zonaria and Cystoseira occurred in notably higher densities and were considered subdominants in the Interstate Electronics Corporation areas.

Allopora was not reported by either survey. SAI reported hydroids, anemones, bryozoans, and sponges as the dominant sessile invertebrates. In contrast, sessile invertebrates (sponges and crusts) were observed rarely at the Interstate site.

- Cortes Bank (Area B) - Data from North Cortes, (Littler et al., 1978) (SAI) with data from Interstate dives 13 (time = 1017), 15 (time = 0734), and 14 (time = 1855). Data were recorded from overlapping areas. All sites were located in areas of rock ridges, with additional boulders, cobble, and sand channels reported at the Interstate sites. The communities were similar at all sites. Both surveys reported Eisenia arborea as the dominant macroalgae with an extensive understory comprising red and brown algae, and sessile suspension feeding invertebrates including hydroids, bryozoan, and sponges.

- Tanner Bank (Area E) - Data from North Tanner, (Littler et al., 1978) (SAI) were compared with data from Interstate dive 6 (time = 1333). Data were recorded from areas that were 180 m (0.1 nm) apart. The SAI site is an area of rock ridges, in contrast to the Interstate site which consists of both cliff ledges and sand channels. Both surveys reported that encrusting coralline algae is common. Interstate reports that Agarum is dominant on cliff ledges (to 15/m) whereas Agarum was not reported by SAI. Allopora was common at both sites reaching 50% cover on cliff ledges.

- Tanner Bank (Area E) - Data from South Tanner, (Littler et al., 1978) (SAI) were compared with data from Interstate dive 7 (time = 1750). Data were recorded from areas 54 m (.03 nm) apart. Both sites were located in areas of low rock relief. The communities were similar in both areas with encrusting coralline algae comprising the dominant algae cover. A notable difference between the surveys is that the brittle star Ophiothrix was reported to be the dominant invertebrate by SAI but was only reported as present in low densities by Interstate.

- Tanner Bank (Area F) - Data from Ecomar (1978) were compared with data from Interstate dives 6 (time = 1352) and 3 (time = 1213). Data were recorded from areas that were 610 m (.33 nmi) (dive 6) and 460 m (0.25 nmi) (dive 3) from the Ecomar site. Because of the method of data reporting these results could only be partly compared. All sites were located in areas of rock ridges with some areas of sand channels. The communities were similar in both areas: both surveys reported encrusting coralline algae and Agarum fimbriatum as the common macroalgae.

Section 4

CONCLUSIONS

The Banks are situated at the edge of the Continental Shelf, lying along an interface between open-ocean currents and the Southern California gyre. Deep-water mixing and variable relief produce upwelling and surge as deep as 100 m (330 ft.) Limited temperature data, the influence of the California Current, and species extensions from northern populations suggest that the Banks may represent an area of decreased overall water temperature. These conditions combined with high water clarity in areas of rocky substrate and the isolated position of the Banks in an essentially unpolluted environment produce an area of high productivity with macroalgae occurring in high densities down to 60 m. Additional evidence of this high productivity is seen in the abundant and diverse fish, coral, sponge, echinoderm, and mollusc populations found in the area.

Coelenterates (36 species), sponges (14 species), molluscs (40 species), echinoderms (38 species), fish (67 species) and algae (39 species) were the most diverse and abundant phyla on the banks at the resolution of this survey's methods.

Fish (mostly rockfish) were found to be most abundant and diverse (67 species) over the rocky bottom above 120 m depth yet no obvious correlations with a specific benthic community were seen. Below 120 m depth rockfish, combfish, and ratfish were the dominant fish seen. However, these species also ranged into shallower water. The shallow water fish, less than 60 m, were vertically stratified into three general zones. From the bottom up, they are: a sea bottom feeding zone (blackeye goby and rockfish), a water column planktivore feeding zone (blacksmith, senorita, squarespot rockfish) and a predatory zone (ocean whitefish, bocaccio, olive and blue rockfish). The maximum depth of senorita was found to be extended from the presently known 54 to a depth of 100 m and is related to the depth extension of the biological communities.

Several fish species were conspicuously absent from the Banks. Factors responsible included a lack of shallow areas for breeding and nursery areas (i.e., exposed land masses and protected shallow water), limited dispersal to offshore areas, and the relative isolation of the Banks.

The dominant hydrocoral species was Allopora. Three species of cup corals, two stony corals and 17 species of fan corals were also observed in the area. The fan corals Eugorgia rubens and Plumarella longispina reached sufficient localized densities to be considered subdominants and were included in the community definitions. Three corals represented range extensions while the remaining have been previously reported from the Southern California Bight in similar depth ranges.

Marine organisms commonly occur in bands or zones that are characterized by specific groups and environmental conditions. Recurring species groups are defined as communities and are usually named after one or two dominant organisms.

Community boundaries typically followed depth contours with great consistency, but were interrupted by areas of sand.

Five major communities including eleven subcommunity species associations (Table I-1) were distingushed from the submersible survey data for Tanner and Cortes Banks. They included: the sea palm/erect coralline algae (Eisenia/Calliarthron) community above 40 m, the large-bladed brown algae (Agarum/Laminaria) community 40-60 m, the deep encrusting coralline community below 60 m, the sea lily/brittle star (Florometra/Ophiuroid) community below 89 m, and the sand flat community throughout the survey depth range. Local occurrences of benthic organisms that did not correspond to the depth zonation were related to the northwesterly current structure which produces a more exposed habitat on t e northwest slopes and a more protected habitat on the southeast slopes of the banks.

Minor community differences (changes in subdominant species) were associated with rock relief and exposure relative to the northwesterly current structure. Additional differences were associated with areas of sand scour and sediment transport. The primary differences between areas were that:

- Well-developed sea palm and erect coralline algae communities (Eisenia/Calliarthron) occurred only on Bishop Rock, Nine Fathom Reef and Central Tanner Bank (Areas A, B, and E).
- The sea fan/starfish and red algae subcommunities (Eugorgia/Mediaster and Gelidium) were essentially limited to Bishop Rock (Area A).
- The brittle star (Ophiothrix) subcommunity was limited to Central Tanner Bank (Area E).
- The densest populations of the sea lily and brittle starfish subcommunity (Florometra/Ophiuroid) were essentially limited to Tanner Bank and Santa Rosa Ridge (Areas E, F, and G).

The benthic algal communities represent most of the algal productivity of the Banks and thus much of the food and shelter available to the resident species. The sea palm/erect coralline algae and large-bladed brown algae communities occurring in water depths less than 60 m support a higher diversity and biomass of organisms (including corals, fish and algae) than the communities in regions below 60 m depth.

Since algal production and distribution may be directly related to water clarity it may be assumed that any significant change in water clarity would have an overall effect on the total productivity of the Banks.

The hydrocoral Allopora californica was patchy throughout its distribution, (18 to 123 m), and occurred in all areas except G (Santa Rosa Ridge) which was apparently too deep. Colonies were found to be associated with exposed northwest slopes on boulder and ridge tops below 30 m and mostly on sides of rocks in shallower areas, apparently maximizing exposure to the currents while minimizing storm damage. However, in the shallowest, presumably maximum-energy regimes, Allopora was not found and this may be attributable to storm breakage of the brittle branches. This hydrocoral was also absent from areas which were subject to sand scour or silt deposition. It may be concluded that Allopora californica requires moderately high energy currents or surge essentially free from silt or sand. Most of these colonies were pink or red in color with only small stands of the more typical purple variety being found at 45 m depth north of Bishop rock and at 96 m on Northwest Cortes Bank. Only on Northwest Cortes was Allopora commonly seen below 70 m depth.

Allopora was most frequently seen between 27 and 72 m depth with peaks between 27 to 37 m and 45 to 62 m. The total habitat was estimated to be 16.7 km with 5.2 km being considered as marginal (sparsely inhabited by small colonies). Compared to the total area surveyed, Allopora habitat amounted to only 3-8% of the Banks. Sixty-six percent of the main Allopora habitat (7.6km) included colonies taller than 7 cm. The habitat for Allopora over 7 cm tall is most extensive on areas A (2.4 km), B(1.6 km), and E (3.4 km) with only small amounts reported for areas C (0.3 km) and F (0.5 km). Allopora comprised less than 5% coverage in 96% of the observations made on this coral. The densities observed reflected the extreme patchiness of this coral. The sparsely inhabited marginal habitat was found to have a density of 0.04 colonies/m . The main Allopora habitat consisted of two regions, a moderately dense area of 0.24 colonies/m and a dense area of 0.75 colonies/m.

The standing crop (biomass) of Allopora was estimated to be 350,000 kg (390 tons). On a sustained yield basis, only 7,000 kg could be harvested annually with only 2,800 kg from SCUBA diving depths (45 m). The current value of the resource for recreation probably exceeds the potential value of the harvestable Allopora resource. Also, the scientific value of the Banks as a relatively undisturbed habitat for a wide range of Southern California Bight species argues favorably for minimal harvesting.

A detailed discussion in Volume II compares the communities and associated species observed at Tanner and Cortes Banks during this survey with previous studies conducted on the Banks and in rocky subtidal areas of the Southern California Mainland and the Channel Islands. A special review and comparison of our data with unpublished data and personal observations completed by Dr. Robert Given (Channel Islands), and Jack Word, Mike Moore and Leslie Harris (Southern California Mainland) is reported in Volume II.

The communities and species observed during previous surveys of Tanner and Cortes Banks are similar to those seen during the present survey. A site specific comparison was made between the survey data collected in this study and five previously surveyed sites at Tanner and Cortes Banks (1976-77 SAI subtidal study and 1978 Ecomar study). The differences observed in subdominant species distributions may be attributed to (1) substitutions of functionally equivalent species, (2) local species associations and behavior resulting in a locally patchy distribution, (3) large changes in the substrate composition from elevated rocky reefs, to boulders, to sand, and (4) differences between the surveys in the relative size of area studied and methods used for observation.

Many of the species observed during the present survey are similar to those observed along the Southern California coastline and the Channel Islands although relative abundances of many species differed considerably. (R. Given, unpublished review; Word et al., unpublished review.)

Of major biological significance is the fact that the depth ranges and deepest depths where some communities and species were found are greater on the Banks than have been previously noted for the Southern California Bight. The extreme water clarity results in the expansion of algal community depths from less than 50 m (165 ft) to over 100 m (330 ft). Corals showed range extensions into shallower waters as compared to both northern and southern populations probably as a result of the banks location between open ocean currents and the Southern California Gyre.

In general, most of the fish observed at Tanner and Cortes were within documented depth ranges, with only a few species deeper than previously recorded; however, many species of algae and invertebrates showed increased depth ranges and deeper depths of occurrence. This differential is due to the more extensive data base for depth distribution of fish, due to commercial and sport fisheries for many species.

Also of major significance is the occurrence of species previously known only from more northern or southern waters. Such occurrences show that Tanner and Cortes Banks are an important area of overlap of northern and southern species distributions. The extension of depth ranges of many species and the high diversity of corals and other organisms in the study area demonstrates that the Banks act as an important refuge for many Southern California Bight organisms currently disappearing from more heavily impacted nearshore areas.

Section 5

RECOMMENDATIONS

5.1 GEOLOGY

- As in this study, the combination of side scan and bathymetry should be used in the future in mapping shallow water high-relief environments.
- More survey cross lines should be surveyed for sounding verification and feature enhancement.
- High-resolution subsurface profiling should be used in addition to bathymetry to delineate thin surficial sediments.
- Side scan data should be analyzed for geomorphological structures by detailed isometric reconstruction of the side scan records.

5.2 BIOLOGY

- Manned submersible techniques should be utilized for reconnaissance surveys over large, deep, high relief study areas.
- Cross-transects should be used to check the consistency of information between transects and observers.
- Direct observation by trained scientists is recommended over the separate use of any photographic techniques.
- The combination of multiple data collection techniques (i.e., biological observer, video camera, and Benthos camera) is highly recommended as a means to gain a most comprehensive record and to prevent information loss resulting from failure if only one system were used.
- Paired day and night submersible dives should be conducted at specific sites in each of the major communities to document diurnal differences in the biota.
- Information on benthic communities and species distributions should be supplemented by a sampling program designed to measure specific biological parameters such as productivity and re-establishment rates.
- Specific analyses, such as association analysis, factor analysis, inverse factor analysis, and trend surface analysis, should be applied to further study and summarize the data collected.

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